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PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53 (c).

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TITLE OF THE INVENTION (500 characters max)

MAPPING A TRANSPORT STREAM INTO IP PACKETS FOR WLAN BROADCASTING SERVICES

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ENCLOSED APPLICATION PARTS *(check all that apply)*

☒ Specification *Number of Pages* 8 ☐ CD(s), Number

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METHOD OF PAYMENT OF FILING FEES FOR THIS PROVISIONAL APPLICATION FOR PATENT

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☒No.

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Respectfully submitted, SIGNATURE [signature]	Date: JANUARY 9, 2003
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USE ONLY FOR FILING A PROVISIONAL APPLICATION FOR PATENT

Express mail: EV 194865385 US PU030015

MAPPING A TRANSPORT STREAM INTO IP PACKETS FOR WLAN BROADCASTING SERVICES

As a new application using a Wireless LAN (WLAN) in a hot spot (hotel lobby, airport, shopping mall, café, etc), wirelessly broadcasting live TV programs to WLAN-enabled mobile devices is attractive to many medium providers, such as FOX, NBC, ABC and CBS. Currently, in those high-volume traffic hot spots, a TV set tunes to a pre-set channel (e.g. CNN in an airport) and viewers have no choice of selecting different programs no matter he/she likes the program or not. With the WLAN deployment and WLAN-enabled devices, wirelessly broadcasting a number of TV programs in such a hot spot to those WLAN-enabled devices is a cost-effective way to attract a larger number of eyeballs for the medium companies. On the other hand, a viewer has his/her own private viewing environment, rather than watching a common TV program with everyone else.

Currently, the TV broadcasting studios broadcast TV programs in digitally compressed MPEG-2 streams. Those streams are packetized into MPEG-2 Transport Streams (TS) for distribution over a satellite network. When those streams are received at hot spots and re-broadcasted over an IP based WLAN, mapping from the transport stream to IP packets must be performed.

This invention proposes a unique mapping from an MPEG-2 TS into IP protocols to serve IP based MPEG-2 broadcasting services.

An MPEG 2 transport stream comprises a set of multiplexed compressed audiovisual programs as well as related program information about these carried programs. Such MPEG2 transport streams are broadcasted in satellite, terrestrial, and cable networks. The receiver (e.g. a set top box) receives the entire transport stream (several programs), demultiplexes it, decodes and displays a particular audiovisual program according to the user choice.

The solution of broadcasting an MPEG2 stream in an Ethernet LAN is to simply carry the MPEG2 transport stream packets over the UDP and IP multicast/broadcast protocols. This method requires a significant amount of processing power in the terminal to demultiplex the MPEG2 transport stream. In the context of WLAN where the terminal is a mobile device, such as a PDA or cellular phone, power consumption and CPU processing power are very critical to do all the processing.

This invention proposes a novel MPEG-2 transport stream distribution method over an IP network, especially a WLAN. It relies on a pre-processing, including demultiplxing and mapping, of MPEG2 transport stream before distribution in a wireless network in such a way a terminal needs to listen to and process only the packets relative to the program the user is interested in. In addition the invention proposes several possibilities to reduce the amount of bandwidth that would have been required to transmit the original MPEG2 transport stream. Furthermore, the fact that the MPEG2 transport stream is demultiplexed in the network allows the possibility to transcode the MPEG2 program streams with the different bit rate requirements.

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Key Aspects of the Invention:

1. Method and apparatus for demultiplexing a composite MPEG transport stream into elementary streams, extracting the program related information and repackaging the program information into a well known multicasting IP address for consumption in a closed IP network.
2. Mapping the aforementioned elementary(audio and video pairs) streams into a multicasting IP transport

IETF RFC 2250

[1] specifies a scheme to carry an MPEG-2 TS in RTP payload. In this scheme, a RTP payload contains an integral number of MPEG-2 transport packets, each with 188-byte length. This scheme relies on the receiver to do all the MPEG-2 TS processing, including de-multiplexing, extracting program information from PAT and PMTs, and forming elementary streams (ES) of programs from multiple transport packets. This scheme not only requires significant processing power in a receiver, but also reduces the channel bandwidth requirement to deliver MPEG-2 TS over a RTP/UDP/IP stack for broadcasting services.

Introduction

Mapping an MPEG-2 TS into IP packets for video broadcasting service requires special consideration of the characteristics of a TS. MPEG-2 TS protocol was designed to carry digitally compressed video over a Constant Delayed Network (CDN), such as cable or satellite networks. In addition to the audio and video contents in an Elementary Stream format, extra information about the underlying programs is carried in a TS as well to ease the receiver to select a desired program. Such extra information is called Program Specific Information (PSI), including Program Association Table (PAT), Conditional Access Table (CAT), Program Map Tables (PMTs), identified by designated Packet Identifiers (PIDs). When mapping from an MPEG-2 TS into IP packets for broadcasting services, one must take special care about the extra information on the programs:

- They must be carried over a well-known IP address and port, and therefore all the hosts in that subnetwork can receive them without pre-configuration;
- They have to be transmitted at certain minimum interval so that a receiver can capture the program information so quickly that it can tune to a program without noticeable delay;
- They have to be transmitted using as little channel bandwidth as possible to conserve the bandwidth.

The last two requirements are contradictory to each other. A trade-off design must balance those goals in a systematic way.

In an IP based network, Real Time Protocol (RTP) over UDP/IP is used to encapsulate video or audio packets. This RTP/UDP/IP protocol stack has many features embedded in those protocol headers similar to the features in an MPEG-2 transport stream. We examine and compare MPEG-2 TS with RTP/UDP/IP stack to find the mapping to achieve the following two goals:

- The network under consideration is a WLAN with limited channel capacity. Reduce the overhead and minimize the bandwidth is essential;

- A WLAN-enabled receiver usually has limited CPU and memory resources. Simplifying the processing of an incoming video/audio stream in such a receiver is a key requirement for PDA and cellular phone devices to be able to run such a broadcasting application in real-time.

This invention proposes to do as much pre-processing in the transmitter side as possible to reach those goals.

A Wireless Video Broadcast Network System

Figure 1 illustrates a basic video broadcast service system using a WLAN network. The MPEG2 source may be a local multimedia server or a digital signal received from a satellite transponder. The MPEG2 source can be an MPEG2 transport stream or a program stream.

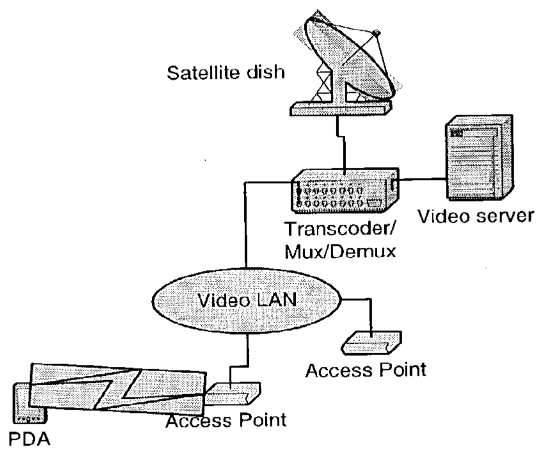

Figure 1: A video broadcast system over a wireless network.

MPEG2 Transport Stream

In a terrestrial broadcasting system, MPEG-2 Transport Stream (TS) carries audiovisual contents in fixed-sized packets. Figure 2 shows the process of generating an MPEG-2 TS from uncompressed video and audio. A program consists of at least one elementary video and one elementary audio stream. Multiple video (different viewing perspective) and audio (different languages) elementary streams in a program is permissible. All the packetized elementary streams of several programs and the Program Specific Information (PSI), including Program Association Table (PAT), Program Map Table (PMT), Network Information Table (NIT) and Conditional Access Table (CAT), are multiplexed into a transport stream. Each transport packet belongs to a particular elementary stream (either a video, audio or PSI). The packet identifier (PID) is used to address each corresponding elementary stream. This process is illustrated in Figure 2.

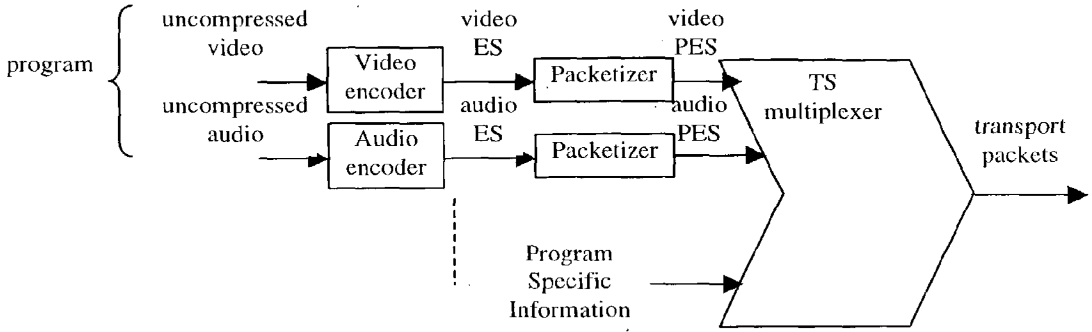

Figure 2. Process of generating an MPEG-2 transport stream from uncompressed video and audio data.

The MPEG2 Program Specific Information (PSI) is composed of different tables that provide information about the programs transported in the Transport Stream. Figure 3 illustrates the hierarchical relationship between the PAT (Program Association Table), the PMTs (Program Map Tables) and the programs that a TS carries. A PAT is always identified by PID=0. In a PAT, all the programs are listed and each program is referenced by a PMT whose PID is associated with the program in the PAT.

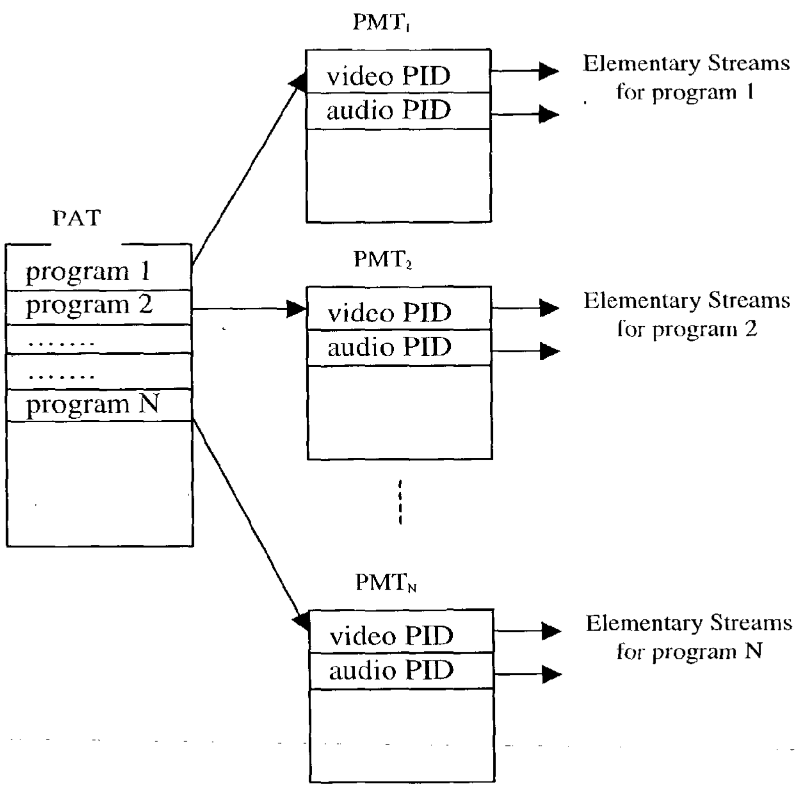

Figure 3. Hierarchical relationship of programs, PAT and PMTs.

In a proposed WLAN broadcasting system (see Figure 1), Multiple TV programs carried in an MPEG-2 TS is re-broadcasted to all the WLAN-enabled devices within a WLAN coverage area. From a satellite transponder, a receiver receives an MPEG-2 transport stream consisting of fixed-sized transport packets. As suggested in

[1], those transport packets can be directly encapsulated into an RTP payload and carried over an IP-based WLAN. This approach has the following drawbacks:

- It relies on the receivers to process (de-multiplex) the transport stream. For mobile terminals, the CPU power is limited and should be dedicated to other important tasks, such as video and audio decoding and displaying.
- All the transport packets will be carried over in RTP payload, whether the receivers require them or not. This wastes precious bandwidth in a WLAN.
- All the video or audio transport packets are encapsulated in a RTP traffic flow with the same destination address and port number. The receivers have to process all the RTP traffic with the TS payload even most packets are dropped on the floor.
- There are some redundancy information carried in both transport packet and RTP headers

In this invention, we propose a novel mapping from an MPEG-2 TS to IP-based RTP/UDP/IP stack for broadcasting service in a WLAN to achieve the aforementioned goals. All the mapping functions may be performed in the transcoder shown in Figure 1.

Considering a mobile device (PDA) that is a thin-client-like host with limited CPU and memory resources, we should move as much of the processing function from a client to the server as possible, such as de-multiplexer function. When a transcoder receives a transport stream, it de-multiplexes the stream based on PIDs assigned to each transport packet. This de-multiplexing function extracts several components from a transport stream: video and audio PES/ES associated with programs and PSI (PAT and PMTs). The broadcasting service in a hot spot which could be free of charge for the subscribers or have a subscription model. The conditional access system is then simply the access control mechanism used in the communication layer. Encryption/Reencryption of content is not envisioned. Therefore, the conditional access table (CAT) in an MPEG-2 TS is ignored in the processing. Notice that not all the programs received from a transponder are to be rebroadcasted in a WLAN broadcasting service. Those undesired elementary streams are discarded in the processing to reducing the processing time and the WLAN bandwidth.

Having de-muxed and re-assembled the PSI and all the elementary streams for WLAN broadcasting service, the transcoder maps each broadcasting elementary stream of a program into a RTP traffic data flow. The RTP packets are encapsulated in multicasting addresses (e.g. Class D IP addresses) and then transmitted over a WLAN. The multicasting addresses used to carry the elementary streams are announced by the PSI packets.

When MPEG-2 video and audio elementary streams of a program are carried in a RTP payload, video and audio may be encapsulated into separate RTP traffic flows with distinct RTP payload types

[1]. This encapsulation of separating video and audio requires a receiver synchronizes video and audio for lip synch. Another encapsulation [3] proposes a bundled video and audio elementary streams belonging to the same program into a single RTP traffic flow for multicasting. This bundled encapsulation provides a coherent

synchronization between video and audio. This bundled encapsulation of video and audio in a single RTP traffic flow is preferred.

To ensure that all the hosts connecting to the broadcast access point to receive the PSI for program selection, the PSI must be sent to clients along with the audiovisual streams to aid user to choose broadcasting programs. There are two approaches to do that. The first approach directly maps PSI tables in their original formats (PAT and PMTs with some modifications) into a well-known multicast address. Due to the different addressing schemes used in MPEG-2 TS and IP network, the transcoder must insert the multicasting IP address for each program in its associated PMT. In a PMT, only PIDs are used to point to its associated video and audio elementary stream. When a multicasting IP address is inserted into a PMT, additional byte space is required to store the IP address. The descriptor field in a PMT [2] can be used to store and carry the multicasting IP address. After the insertion of the multicasting IP address in a PMT, the CRC in the PMT must be re-calculated due to the modification of the PMT. The PAT and the PMTs information are processed to form the new program specific information (PSI) packets carried over UDP/IP using a well-known multicast address. The second approach is to define new PSI protocol suitable for a WLAN based video broadcasting service. The PSI protocol is carried over the same well-known multicast address and delivered to all the hosts within WLAN coverage area. The second approach provides a means to support some proprietary data in the PSI. In either approach, the packets carrying the PSI are called PSI packets to distinguish them from the packets carrying the elementary streams.

To reduce the receiver processing time when such program information remains the same (no changes in PAT and PMTs), a reserved bit in a PSI packet may be borrowed as a *new* flag to indicate that all the PSI remains the same or not since the last transmission. If any changes occur since the last transmission, the *new* flag is set (=1). Otherwise, the *new* flag is reset (=0). The entire processing is depicted in Figure 4. In that figure, the PSI table direct mapping and bundled RTP encapsulation approaches are illustrated.

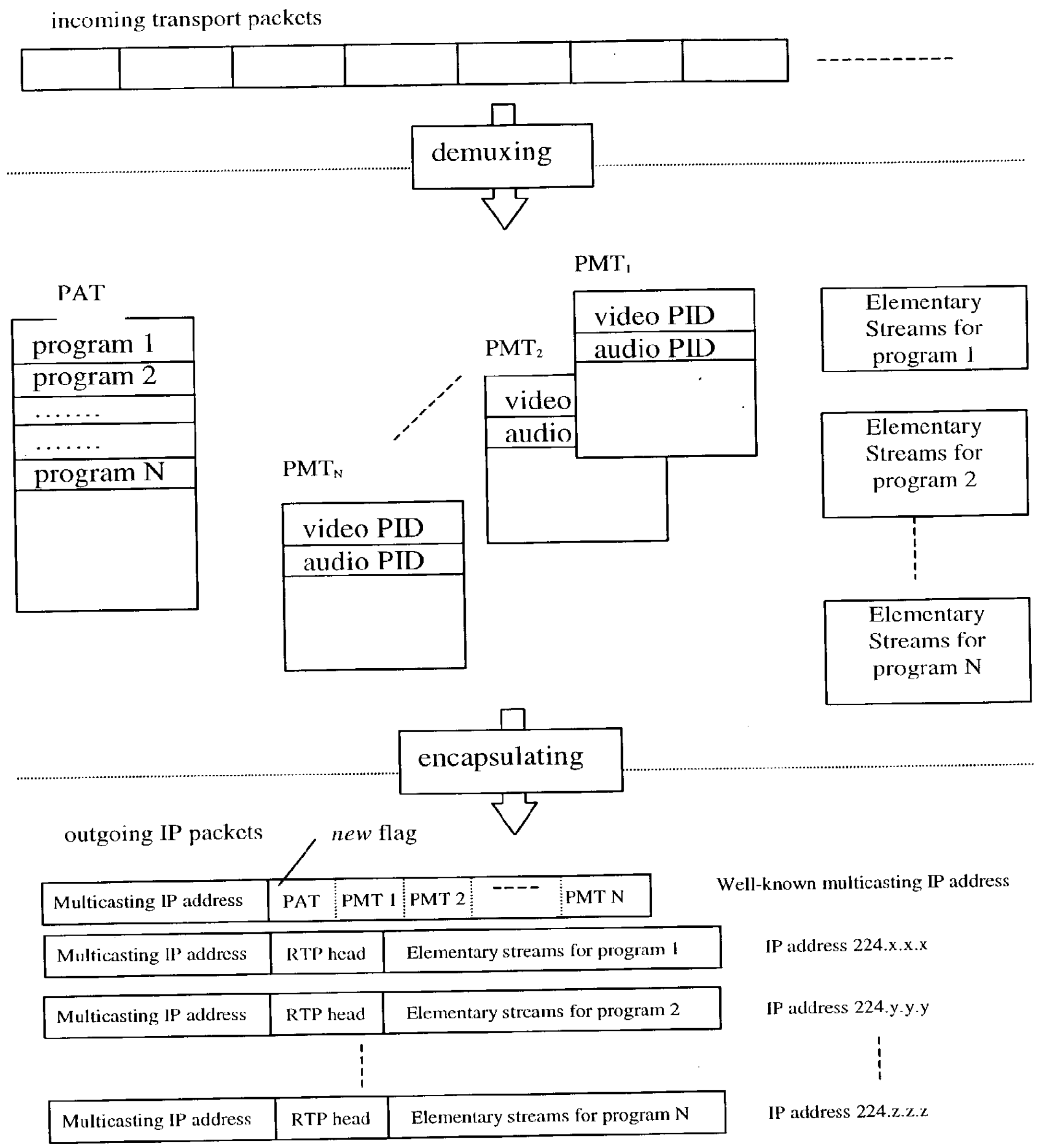

Figure 4. The demuxing and encapsulating processing in the transcoder.

Client software in a mobile device first processes the PSI packets encapsulated in the well-known broadcast address to restore the program specific information stream in order to compose a program map, including the list of elementary streams for each program and their corresponding multicast addresses. The client may ignore the subsequent PSI packets as long as the *new* flag remains reset. The program map must be re-built in a client once the *new* flag is set in a received PSI packet. When a user requests to view a program, the client extracts the multicasting IP address from the program map and then only listens to the IP packets destined to that multicasting IP address. When a user switches to a different program (like a user change viewing channel on a TV), the client

software first locates the associated program information from the program map, extracts the multicasting address(es) associated with that program and listens to the packets destined to the selected multicasting address(es). This way, the client software can select various programs by listening to different multicasting addresses.

In our proposed mapping, transport packet (TP) headers are eliminated during the mapping due to the redundant fields specified both in the TP header and RTP header. In a TP header, the relevant fields for a broadcasting is *continuity_counter* and Program Clock Reference (PCR) (PCR is inserted in an adaptation field of a TP header and the adaptation filed is optional for a TP.) The *continuity_counter* is used for a receiver to detect any packet loss. However, a field called *sequence_number* is specified in a RTP header, which plays a similar role. PCR is used to precisely synchronize the clocks of receiver and transmitter in a constant delayed network. This clock synchronization may be simplified in other means. (e.g. using the timestamp in RTP header)

In an MPEG-2 transport stream, elementary streams are usually encapsulated in a packetized elementary stream (PES). The PES header carries various rate, timing, and data descriptive information, as set by the source encoder. One option is to map an entire PES packet directly to a RTP packet to reserve all the information carried in a PES header. However, most of the fields in a PES header are optional. The most relevant field in a PES header to a broadcasting service is the Presentation Time Stamp (PTS). This PTS of MPEG-2 picture or audio frame can be carried in the timestamp field in a RTP header. The RTP packets carry the same picture or audio frame should have the same timestamp.

To reduce the overhead of RTP/UDP/IP headers (total 40 bytes), a standard compression scheme [5] may be applied. This compression algorithm compresses the combined RTP/UDP/IP 40 byte header to a 2 byte when UDP checksum is not sent, 4 bytes otherwise.

Reference:

[1] D. Hoffman *et al.*, "RTP Payload Format for MPEG1/MPEG2 Video," IETF RFC 2250, January 1998.

[2] ISO/IEC International Standard 13818-1, "Generic Coding of Moving Pictures and Associated Audio Information: System," 1996.

[3] M. Civanlar, G. Cash and B. Haskell, "RTP Payload Format for Bundled MPEG," IETF RFC 2343, May, 1998.

[4] H. Schulzrinne, S. Casner, R. Frederick and V, Jacobson, "RTP: A Transport Protocol for Real-Time Applications," RFC 1889, January, 1996.

[5] S. Casner and V. Jacobson, "Compressing IP/UDP/RTP Headers for Low-Speed Serial Links", RFC 2508, February 1999.

[redacted]